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Significant Natural Areas

ABSTRACT

The Sierra Nevada Ecosystem Project mapped 945 areas in the Sierra Nevada of ecological, cultural, and geological significance. These areas contain outstanding features of unusual rarity, diversity, and representativeness on national forest and national park lands. More than 70% of the areas were newly recognized during the SNEP project. Local agency specialists familiar with local areas mapped 553 ecological areas (average size 1,359 ha [3,349 acres]), 198 cultural areas (average size 2,371 ha [5,804 acres]), and 194 geological areas (average size 3,822 ha [9,443 acres]) during workshops held throughout the Sierra Nevada. Ecological and cultural areas are concentrated primarily in the southern Sierra, especially in the national parks, and secondarily in the northern and eastern Sierra. Geological areas concentrate somewhat at high elevations and along river corridors. Although more than a third of these areas are in "protected" designations (wilderness, natural reserves, parks, etc.), more than half were recorded as having had past impacts to biodiversity values from recreation and other intensive human uses. Forty percent have had impacts from grazing. The areas with these impacts are scattered through the Sierra Nevada. Both of these activities are permitted in many significant areas within "protected" designations, which suggests that land designation per se may not adequately maintain the biodiversity values for which these areas are recognized. Timber harvest and associated impacts were noted on about a quarter of the areas, concentrated in a few primarily west-side forests. Mining and pollution were minor and local impacts to a small percentage of sites. Collectively these areas represent a network of sites identified for superlative values across the Sierra Nevada. Site-specific evaluation and coordinated management with adjacent and matrix lands at the landscape level would most likely promote the greatest maintenance of biodiversity values over the range.

INTRODUCTION

This chapter reports on areas of natural diversity in the Sierra Nevada, which SNEP refers to as significant areas. SNEP defines significant areas as "lands in the Sierra Nevada that contain special features of ecological, cultural, or geological diversity; a feature is special if it is unusually rare, diverse, or representative of natural diversity." SNEP distinguishes significant areas from natural areas primarily on the basis of management implications. Natural areas are "lands that may contain special features but, more importantly, are managed to maintain or restore a state of naturalness or wildness" (Bonnicksen 1988; UNESCO 1974, 1984; World Resources Institute 1991). Some level of human use has occurred on most of these lands, and in SNEP's context, naturalness implies less the absence of humans than the dominance of nonhuman ecological processes and structures (Diedrich et al. 1994; Hoerr 1993). Management of natural areas, as old-growth areas, criti-

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cal watersheds, and wildlife habitat, often centers on the concept of reserve management. A reserve management strategy "promotes protection of natural habitats by restricting human use and access." Many categories of natural areas and reserve management exist (e.g., World Resources Institute 1991). In the context of SNEP, significant area, as a category of land, does not a priori imply a certain type of management. As discussed later, the special features within SNEP significant areas are heterogeneous, not only in their identifying attributes, but in the ways they are assessed and in their management needs.

OBJECTIVES

The SNEP significant areas project was primarily an inventory effort to map and compile information about features in the Sierra Nevada that have special ecological, geological, and cultural significance. The project did not attempt to be exhaustive but rather to contribute to the list of areas already known for the Sierra Nevada. By inventorying these areas and their special attributes, SNEP highlighted their existence, general condition, and potential management needs.

Specific objectives in some cases overlap, and are accomplished by, other SNEP efforts. Collectively, the work in SNEP to identify habitats and areas of high ecological value for late successional forests, for watersheds, for endemic plants and animals, for genetic diversity, and for significant areas have a common goal of inventorying biodiversity in the Sierra Nevada. Collective objectives of SNEP projects that involve in situ biodiversity areas are to

- Compile, in GIS format, map and attribute information about previously designated natural areas, for example, wilderness, national parks, and research natural areas (Davis et al. 1996).
- Standardize approaches to selection, size, and coverage of significant areas in the Sierra Nevada; expand criteria beyond rare elements; include ecological, geological, and cultural features. Map new areas on the national forests and national parks of the Sierra Nevada, and enter them into the SNEP GIS, achieving a broad coverage of landscapes. Collect standard attribute data (this chapter).
- Inventory, map, and assess aquatic significant natural areas (Moyle 1996).
- Assess areas of concentration and management of significant plant communities and botanical resources in the Sierra Nevada (Davis et al. 1996; Shevock 1996).
- Evaluate conditions of resources broadly within the SNEP significant areas, recognizing relationships with past management, trends for the future, and management options.

These objectives derive from the five SNEP assessment and policy questions.

The following assumptions underlie our analysis of natural areas:

- Significant areas make up a heterogeneous class. Definitions of significance are arbitrary and relative to geographic scale, to biodiversity values, and to human values.
- Previous and ongoing efforts exist in the Sierra Nevada to identify natural and significant areas. SNEP's work adds to, and does not replace, these efforts.
- Because of the nature of significant areas, the SNEP significant areas mapping effort does not try to be exhaustive. Many more areas exist in the Sierra Nevada that fit the criteria and were not inventoried, either because they are unknown or because SNEP did not reach an expert who knew about them. SNEP's goal was to add to existing inventories in a systematic way.
- The significant areas inventory was based on expert-opinion knowledge; on-the-ground evaluation of significant areas was not undertaken.
- Many categories of mappers could have been used (academic, public, agency). Each has its own type of knowledge of the landscape and biases about what significant areas are. SNEP used local agency specialists, who have intimate, broad knowledge of Sierra Nevada places and who have not been systematically queried in past natural area inventories.
- SNEP focused more on locating special features of the Sierra Nevada and less on mapping areas that contain them. Thus, boundaries are rough, indicating general locations of features, and are not intended to be formal management boundaries. Site-specific management (not within SNEP's scope) would address appropriate boundaries.
- Uniform management of significant areas in the Sierra Nevada is not implied by SNEP's recognition of an area as special. SNEP assumes that the diverse features mapped in significant areas have varying management needs and priorities for protection, and that appropriate management would not automatically lead to set-aside areas of exclusive or restrictive use.

BACKGROUND

The concepts of specialness and diversity are inherent to SNEP's criteria for choosing significant areas. A brief background is developed here to explain the logic that underlies SNEP's significant areas effort.

Significant areas attempt to inventory certain types of biodiversity in situ. Biodiversity can be considered along three "dimensions": biological organization, space, and time.

Biological Organization

Biotic diversity is hierarchic and scalar. Increasingly complex levels of biological organization are recognizable along a continuum from molecules to biomes. Genes are fundamental units of biodiversity and are packaged within individuals; interbreeding individuals compose populations; populations of potentially interbreeding individuals define species; species interact within communities and ecosystems; and related communities and ecosystems evolve in response to regional environments and climatic regimes as biomes (Frankel and Soule 1981; Keystone Center 1991; Salwasser 1991; U.S. Congress 1987; Wilson 1988).

Because it is more practical often to inventory or measure composition and structure (e.g., numbers and types of species, stand structures, landscape patterns), we tend to bias our thinking toward this aspect of biodiversity. In fact, process (e.g., fire, nutrient cycling, reproductive functions) may be the most important focus for sustainable land management. Because composition, structure, and function are related, one may act as a proxy or indicator for another, allowing us to infer from the more practical aspects some of the more hidden or complex aspects of the system. Process, for instance, may most easily be interpreted by analyzing changes in state over time or space.

Space

Diversity at any level of biological organization is played out in space. On the geographic scale, biological diversity is recognized relative to microsites, watersheds, landscapes, regions, or continents (Crow 1991; Diaz and Apostol 1992; Forman and Godron 1986; Interagency Team 1994). Although these levels are arbitrarily defined, they reflect a real hierarchic or nested order. Often, different processes occur and patterns emerge at different geographic scales (Crow 1991; Harris 1984).

Time

Although an intangible dimension of consequence only, time has a practical significance in that we observe different compositions, structures, and processes occurring as a function of years, decades, centuries, or millennia (Delcourt and Delcourt 1991). Further, from a biodiversity perspective, relative time is important: the past is meaningful to the present and to the future, because biotic systems evolve cumulatively through time (Woolfenden 1996; Millar 1996b). Traditionally, land managers and policy makers have short time horizons for planning and have not looked far to the past for information or considered that futures they manage may be different from the present. Recognizing that biodiversity acts on long scales as well has opened the door for managers to view natural systems in their evolutionary context as dynamic and individualistic (Stine 1996; Kinney 1996; Woolfenden 1996; Millar 1996b; Botkin 1990; Delcourt and Delcourt 1991; Kaufman 1993).

Cultural Diversity

SNEP adopts the broadest view of biodiversity to include humans. Like any other species, humans have levels of biological organization and possess habitat attributes in space and time. Humans have lived in the Sierra Nevada for nearly 10,000 years (Bettinger 1991; Blackburn and Anderson 1993; Anderson and Moratto 1996) in compositions (ethnicities, demographics), structures (settlement groups and economic classes), and processes (trade, diet, hostilities, land use and conversion) that have changed dramatically over past millennia and will certainly change over the next decades. Distinctions may be made between ancient and modern cultures, between cultures that practice traditional, extensive land use and husbandry and those that introduce intensive, industrial technologies, and between cultures of native and introduced ancestry. These elements are as much part of the SNEP charge to inventory and assess as are the nonhuman components.

Physical Diversity

Geological, hydrological, lithological, soil, and climatic factors define ecosystems and govern the expression of biodiversity within them. The Sierra Nevada's more than several hundred million year history of uplift, erosion, volcanism, and glaciation has produced a broad suite of rock types, including many kinds of igneous, sedimentary, and metamorphic rocks, with a wide range of ages from Cambrian to Quaternary (Huber 1981; McPhee 1993; Norris and Webb 1990). Soils that have weathered from these rocks range from shallow, residual soils developed over bedrock at high altitudes to deep, depositional soils in valley floors developed over river alluvium. With varying parent materials, land stabilities, and climates, the soils of the Sierra Nevada are even more diverse than their geologic substrates.

METHODS

Criteria for Significance and Guidelines for Selection of SNEP Significant Areas

SNEP's significant area project defined significance as extending to the broad range of biological, cultural, and physical diversity. Many institutional programs for natural or significant areas in the Sierra Nevada have focused on specific aspects of biodiversity, such as the species or vegetation communities level (e.g., old-growth forests, giant sequoia groves, rare species), while other levels are ignored, such as genetic and biome levels, large spatial scales, and ecosystem processes such as nutrient and water cycles.

A first general criterion for significance is that a feature or element is rare, rich, or representative (Bonnicksen 1988; Hoshovsky 1994; Wilson 1988). Rarity, the quality of being uncommon or unusual, is widely discussed in ecology and conservation biology literature for its significance (Bonnicksen 1988; Frankel and Soule 1981; Hoshovsky 1994; Wilson 1988). Rarity is classified and recognized according to evolutionary origin, ecological condition, and geographic position (Fiedler and Ahouse 1992; Rabinowitz 1981; Schoener 1987). For mapping purposes, rarity was standardized to mean features that exemplify significant rare genetic, species, community, ecosystem, cultural, or geological elements. Rare means fewer than about five occurrences on a national forest or national park, or that the national forest or park was the only place where an element occurred in the Sierra Nevada, even if more than five occurrences existed on a national forest or park (i.e., local endemic). Distinctly unusual features were sought for the significant areas inventory. This meant, for instance, that the emphasis was on distinct or unusual phylogenetic elements (e.g., monotypic species), unusual disjunctions (e.g., disjunct population far from main ranges), extreme assemblages (unusual mix of species), unexpected landforms, and so on. Thus, in this category, the inventory sought primarily examples of rare and unusual phenomena and, secondarily, rare examples of common phenomena.

Richness, or diversity, is widely classified and debated for its meaning in ecological and evolutionary contexts (May 1973; Pimm 1986; Turelli 1978). Richness implies a larger than expected number of parts, structures, or processes occurring within an area. For SNEP's mapping, richness was standardized to mean features on national forest or park lands that best exemplify high or unusual genetic, species, community, ecosystem, cultural, or geological diversity. Candidates were considered if there were fewer than about five occurrences of equal diversity on the national forest or park.

The attribute representative is often not as widely acknowledged as being special as rarity or diversity. From the standpoint of ecological role, conservation importance, and human utility, however, the common situations—widespread species (e.g., ponderosa pine, Douglas fir), common vegetation types (e.g., mixed conifer), routine functions (e.g., water, nutrient cycling, fire), "central" ecological niches (optimum habitats)—make up the essence of ecosystems, ecosystem services, and natural resources. Further, in temperate latitudes, including the Sierra Nevada, these common, widespread elements often receive high human impact (Beesley 1996; Duane 1996; Franklin and Fites-Kaufmann 1996; Davis and Stoms 1996; Moyle and Randall 1996). Representatives of common types often contain much of the diversity of rare or rich situations, although possibly in lower frequencies.

Representativeness was standardized as national forest or park lands that best represent common genetic, community, ecosystem, geological, or cultural diversity. Common diversity was interpreted as meaning the best representative elements of a standard classification system (e.g., vegetation series, geological classification, cultural phase). Classifications for representative category were ecological, cultural, and geological.

TABLE 29.1

Example from Tahoe National Forest of vegetation types developed ad hoc for mapping representative significant areas on the national forest. These types were listed by the local mappers to reflect common conditions on the forest. At least one significant area per national forest or national park was chosen to represent each type.

Red fir	Aspen–alder–cotton willow riparian
Mountain hemlock	Aspen (slope)
Mixed conifer	Canyon live oak
East-side pine	Montane chaparral
Big sagebrush–mountain mahogany	Madrone–tan oak
Western juniper	Foothill pine
Knobcone pine	Serpentine
Black oak	Giant sequoia
Subalpine shrub	Lodgepole pine
Montane meadow	Blue oak–white oak
Bog	Western white pine
Fen	White fir

Ecological

Although initially SNEP planned to use a standard vegetation type classification to select representative features, it became clear from pilot mapping sessions that this inappropriately limited choices. The current or pending classifications (e.g., USFS 1992; Allen 1987; Cheatham and Haller 1975; Parker and Matyas 1979; Holland 1986; or Sawyer and Keeler-Wolf 1996) were either too general or too specific for the scale of a national forest or national park and did not represent the mix of types that was specific to each forest or park. Instead, we chose to develop ad hoc vegetation lists that reflected the conditions on each forest or park. Representative areas were then chosen to exemplify each type (e.g., table 29.1).

Cultural

For purposes of choosing representative significant cultural areas, cultural diversity was classified into four categories, based primarily on time:

1. Historic (last 200 years) Indian
2. Historic (last 200 years) non-Indian
3. Archaic (200–6,000 years) Indian
4. Paleo-Indian (more than 6,000 years)

Geological

Representative significant geological areas were classified by age, landform, and rock type as

- Geological age
  - Quaternary: Holocene or Pleistocene
  - Tertiary
  - Mesozoic
  - Paleozoic
- Landform (list not specified; left open)
- Rock type
  - Sedimentary
  - Metamorphic
  - Igneous: Volcanic or Plutonic

A second criterion for significance is type of diversity. SNEP's significant areas project considered biological (ecological), cultural, and physical aspects of diversity in the Sierra Nevada (table 29.2). In the following discussions, if not specified, biological or ecological diversity or significance includes cultural aspects. Together, the two levels of criteria provide a matrix that guided SNEP's selection of special features and areas. Cells within the matrix became targets for finding significant areas in the different parts of the Sierra Nevada (figure 29.1).

In each case, "best exemplify" or "best represent" refers to that element (population, species, plant community, cultural or geological site) among the pool of qualifying areas that is (1) most stable from an ecological, cultural, or geological context (unless the element is obviously a dynamic one) and (2) most viable (population, species, vegetation assemblage, restoration status), largest, most diverse, and has contained within the area the most environmental variability. Size ranges for choosing sites were given as

- less than about 400 ha (1,000 acres) for genetic, species, or cultural features
- less than about 4,000 ha (10,000 acres) for plant communities
- less than about 20,000 ha (50,000 acres) for geological features

These size ranges were merely guidelines and were meant to standardize the relative types of significant areas that SNEP inventoried and to aid mappers in selecting appropriate categories of candidates.

Past or current administrative status was not considered a primary factor in selecting SNEP significant areas. Areas currently designated for reserve status (e.g., research natural areas, special interest areas) were mapped and inventoried by the SNEP Gap Analysis Program (GAP) (Davis and Stoms 1996) and kept in separate GIS layers. Past and current management status affected candidacy when past actions had significantly and detrimentally impacted the special feature for which an area might have been chosen. If the feature persisted despite inappropriate management, and also met other criteria, it could have been included. Selection was intended to be relatively blind to management and administrative status, unless the feature was so impacted by these aspects that it did not function in its natural condition. Although these aspects of management were not considered essential in selection, they were noted in the attribute database and became part of the assessment.

	Rare	Rich	Representative
Genetic			
Species			
Community			
Ecosystem			
Cultural			
Physical			

FIGURE 29.1

Matrix of criteria that defined targets for SNEP significant area project. Each cell was considered a potential target for selecting significant areas within a specific national forest or national park. For the representative criterion, classifications were developed for each type of diversity.

Geographic scale in general was an important aspect defining SNEP's choice of significant areas. Whereas the Sierra Nevada as a whole is considered a significant feature on the continental and global scales, and Yosemite and Lassen National Parks are considered significant features at the Sierra Nevada and national scales, the SNEP significant areas project tried to standardize areas by limiting their sizes, as described. At the sizes suggested, the candidate areas were chosen if they were significant relative to an individual national forest or national park. We did not seek exhaustive lists, for example, of every archaeological site or every rare plant population on a national forest or national park. We attempted to stress elements that were "most special" along the guidelines and at the scales described.

Methods for Selecting and Mapping SNEP Significant Areas

The SNEP significant areas project used an expert opinion and target elements approach. The matrix of criteria (figure 29.1) created the basis for target cells, and the geographic focus was primarily the Sierran national forests and national parks. Mapping sessions were held at central offices on each national forest or park, and an interdisciplinary group of lo-

TABLE 29.2

Examples of criteria for significance used in the SNEP significant areas project at four levels of biological organization, the physical environment, and cultural diversity. Descriptive criteria area considered relative to spatial and temporal scales.

1. Genetic
High diversity
Unique diversity
Rare or threatened genetic types
Important hybrid diversity
Relictual
Refugial
Ecotones/clines/ecotypes
Chromosomal races

2. Species
Rare, threatened, endangered species
Marginal or unusual distributions
Keystone, critical, indicator species
Representative populations or species

3. Community
High diversity of species
Marginal location for type
Important disturbance regimes
Relictual, refugial
Contains rare, endemic species
Unique edaphic situation
Critical role in ecoregion
Pristine, undisturbed
Sharp or unusual ecotones

4. Ecosystem
High diversity
Endangered
High endemism
Critical role in bioregion

5. Physical
Relictual, ancient
Fossil-bearing or otherwise significant paleoecologically
Rare or distinctive
Exemplary of landforms, geologic eras, rock types

6. Cultural
Unique or representative archaeological elements
Highly valued socially
Traditional use
Historic value
Scenic

cal agency staff was convened for each session. The group of mappers was chosen for (1) individual knowledge of the local area, (2) diversity of disciplinary knowledge, and (3) geographic coverage. Staff areas included geology, hydrology, soils, lands and resources, landscape ecology, fire, archaeology, ecology, wildlife biology, botany, recreation, range, and land-management planning. Most sessions had at least fifteen mappers present for a national forest or park.

Specialists mapped on planimetric national forest maps (0.5 in:1 mi or 1:125,000), which SNEP had prepared with registered Mylar overlays. Separate maps were provided for mapping geological, cultural, and ecological areas. Mappers first selected areas of rarity and richness for each category, then developed a forest-appropriate list of vegetation types to serve as targets for the representative categories (e.g., table 29.1); the standard classifications described earlier were used to select representative sites of cultural and geological significance. Some cultural sites were considered too sensitive to release location data. For security, these were (1) mapped very generally with boundaries that would not be detailed enough to locate the specific cultural site (which was often very small), (2) described but not mapped, or (3) excluded entirely.

Mappers were instructed to locate polygons by drawing general boundaries on Mylar overlays. Boundaries were not intended to reflect suggested management units but rather to signify geographic locations of the special feature on the landscape.

For each area mapped, attribute data were collected about area name and location, reason for selection, significant attributes, short- and long-term management (current and future), and past impacts to the resources for which the area was identified (figure 29.2). If an area was already in a protection category such as wilderness, research natural area, or botanical area, this was noted.

Only minimal mapping was done on nonfederal lands. Federal mappers did identify areas of nonfederal public lands (e.g., state parks) if they felt them to be important relative to other federal lands in their region. Agency mappers were instructed to map special features on public lands. Boundaries drawn to identify special features on public lands may have shown pieces of private lands. This was especially the case where private lands are intermixed (e.g., Tahoe National Forest). In these cases, the actual boundaries indicated were done purposely at a coarse level to show the general region of the special features.

A few large industrial landowners in the western Sierra Nevada were contacted directly by SNEP for information on many aspects of SNEP inventories. Mapped information on significant areas with attribute data was contributed by Fiberboard Corporation.

Mapped areas were entered in the SNEP GIS, with attribute data attached in a database.

Due to the exigencies of schedules, the Plumas National Forest could not be mapped. The ecological map for the Eldorado National Forest and the cultural map for the Stanislaus National Forest were not completed in time to be included.

RESULTS

Current Conditions

Designated Reserve Areas

Many areas in the Sierra Nevada have been formally designated by public agencies, academic institutions, and nongovernmental organizations for natural significance. These areas are characterized by histories of low human disturbance and by primary management objectives of resource preservation and reserve management strategy. Many programs for the preservation of natural diversity exist in California (Cochrane 1986; Davis and Stoms 1996; Davis et al. 1996) These types of areas include (administrative authority and number of areas designated in the Sierra Nevada are in parentheses):

- Areas of critical environmental concern (BLM: 11)
- Biosphere reserves (UNESCO: 2)

Polygon Attribute Form
Tahoe NF Significant Areas
Sierra Nevada Ecosystem Project
3/95

Date: MARCH 6, 1995

Mapper(s) name:

Polygon code: 14

Area name (e.g. Devil's Post Pile): Duncan

Watershed:

Reason for selection as a significant area
Ranking is based on four categories: genetic/species significance, ecosystem/community significance, physical/geologic, and cultural/scenic importance and 3 significant criteria rare, rich and representative. If area is selected for representative criteria also indicate what type it represents (e.g. vegetation series or geologic era). Rank the polygon based on these four characteristics, you may use numbers 1-4, with 1 being the most important and 4 the least.

Category	Rare	Rich	Representative	Type	
genetic/species					
ecosystem/community	1	2	3		
physical/geologic					see code form
cultural/scenic					see code form

List of attributes that make the area significant
(e.g. deepest lake in North America, petroglyphs, etc.) Do not exceed five responses and 30 characters per response.

1. Large block of undisturbed mixed conifer old growth
2. high density spotted owls / goshawks
3. Rich botanical
4. Rich ecological

Management

Primary Emphasis (See code sheet)
76

Secondary Emphasis (See code sheet)
51, 52

Long Range Management Goal (see code sheet and cite planning documents)
34, 73

Activities within past 25 years and current impacts to significant value of area
check all that apply

Activities	Impact occurred	Category
		Logging/timber harvest
✓		Grazing
		Road building
		Mining
		Pollution
✓		Recreation (describe, e.g. mountain biking)
		other 1 (describe)
		other 2 (describe)
		other 3 (describe)

FIGURE 29.2

Example of attribute form used to describe information about new significant areas mapped through SNEP.

- Special interest areas (USFS: botanical [23], cultural [8], geological [19], zoological [1], and scenic [5])
- Ecological reserves (California Department of Fish and Game: 7)
- National parks and monuments (NPS: 4)
- Natural preserves (California Department of Parks and Recreation: 6)
- Cultural preserves (California Department of Parks and Recreation: 4)
- The Nature Conservancy preserves (5)
- National scenic areas (USFS: 1)
- Research natural areas (USFS: 21 established, 22 candidate; NPS: 8)
- State historic parks (California Department of Parks and Recreation: 8)
- State parks and reserves (California Department of Parks and Recreation: 10)
- State recreation areas (California Department of Parks and Recreation: 8)
- University of California Natural Reserve System (UC: 5)
- World heritage sites (UNESCO: 1)
- Wilderness areas (USFS: 20, NPS: 4)
- Wild trout waters (California Department of Fish and Game: 15)
- Wild and scenic rivers (state and federal: 9)

Areas within most of these categories are located and identified nonsystematically, with designation posthoc after informal recognition of the area's significance. A few categories have an a priori target system to identify specific elements of significance and systematically search for areas to fit these targets. Special interest areas, for example, are designated to protect significant botanical, cultural, geological, paleontological, scenic, and zoological resources (Cochrane 1986). The Research Natural Areas Program of the U.S. Forest Service systematically surveys areas that represent ecological types administered by the Forest Service throughout the country (Cheatham et al. 1977; Federal Committee on Ecological Reserves 1977). Target matrices based on plant community types (tree, shrub, and understory) have been developed for broad regions of the Sierra Nevada, and exemplary areas are sought to fill the cells (Keeler-Wolf 1985).

The SNEP Gap Analysis Program has digitized maps for designated natural areas in the Sierra Nevada into a GIS, and has completed a database with administrative information on these areas (see Davis and Stoms 1996).

SNEP Significant Areas Inventory

In all, 945 natural areas were mapped and attributed in the Sierra Nevada by SNEP, including 553 ecological areas, 198 cultural areas, and 194 geological areas (table 29.3). These include areas mapped on the Eldorado (ecological areas map not completed), Inyo, Lassen, Lake Tahoe Basin (cultural areas map not completed), Tahoe, Sequoia, Sierra, Stanislaus (cultural areas map being redrawn), and Toiyabe National Forests (Bridgeport District); the Sequoia–Kings Canyon and Yosemite National Parks; and one BLM resource area (figures 29.3, 29.4, and 29.5).

Ecological areas are distributed across the Sierra Nevada (figure 29.3), with concentrations of larger areas in Sequoia–Kings Canyon and Yosemite National Parks and in the southern Sierra and with smaller areas widely distributed in the eastern Sierra. Some regional differences may be due to the interpretations of mappers in different sessions. Cultural areas (figure 29.4) also tend to be concentrated in and around the national parks, in the southern Sierra Nevada, and in the far northern Sierra Nevada. Geological areas (figure 29.5) are more clustered around the high peaks and river corridors.

Mappers often designated sites for several "primary significance" aspects, although we requested only one. Thus, many of the categories overlap in one area, and attributes indicated are not mutually exclusive (table 29.3). Ecological areas were smaller on average than cultural areas, which were smaller than geological areas. The size ranges originally given to the mappers as guides only vaguely matched what they felt to be the actual landscape areas. Geological areas were smaller than we had suggested, and cultural areas were much larger.

Current management of significant areas mapped by SNEP is given in table 29.4. About a third of the areas are currently in some form of land designation intended to protect the biodiversity values, most in significant areas mapped in the national parks, with the remainder in wilderness and a very small proportion in other designations (e.g., research natural areas, special interest areas, wild and scenic rivers, state parks). Among the national forests, the Bridgeport District of the Toiyabe was unusual in mapping many areas in wilderness. About a third of the areas receive some form of intensive human activity (including utility corridors, multiple resource areas, recreation, transportation, administrative sites, experimental forests). About equal proportions of the areas have grazing (14%) and timber (12%) activities present. The east-side forests (Inyo and Toiyabe) had more areas in grazing designations than elsewhere and, with the exception of the national parks, fewer areas where timber activities occur. The Tahoe National Forest had the largest number of significant areas (40%) in timber zones.

Assessment and Trends in Protection of Special Features

Past impacts to significant areas are summarized in several categories (table 29.5). Sierra-wide, over half the areas were determined to have impacts from recreation, and 40% had impacts from grazing. Recreation impacts were distributed in significant areas broadly over the Sierra Nevada. Less than a third of the areas were noted as having past impacts from logging or road construction. Mining and pollution affected only a small proportion of areas (less than 10%).

Considering past management impacts and current management together suggests in general that areas traditionally considered protected for biodiversity values in fact may not

TABLE 29.3

Sierra-wide summary statistics of geographic attributes for significant natural areas mapped by SNEP.

Statistic	Ecologically Significant Areas	Culturally Significant Areas	Geologically Significant Areas
Number chosen primarily for ecological/cultural/ geological significance	553	198	194
Average size	1,359 ha (3,349 acres)	2,349 ha (5,804 acres)	3,922 ha (9,443 acres)
Number of sites containing signficant richness	127	207	68
Average size of sites chosen for richness	1,648 ha (4,060 acres)	2,371 ha (5,840 acres)	2,229 ha (5,491 acres)
Number of sites containing significant rarity	68	108	110
Average size of sites chosen for rarity	1,480 ha (3,647 acres)	2,249 ha (5,540 acres)	4,454 ha (10,971acres)
Number of sites containing significant representativeness	253	144	168
Average size of sites chosen for representativeness	995 ha (2,453 acres)	1,936 ha (4,770 acres)	2,673 ha (6,584 acres)

Total number of areas mapped in the Sierra Nevada: 945
Total average size of areas mapped in the Sierra Nevada: 1,355 ha (3,348 acres)

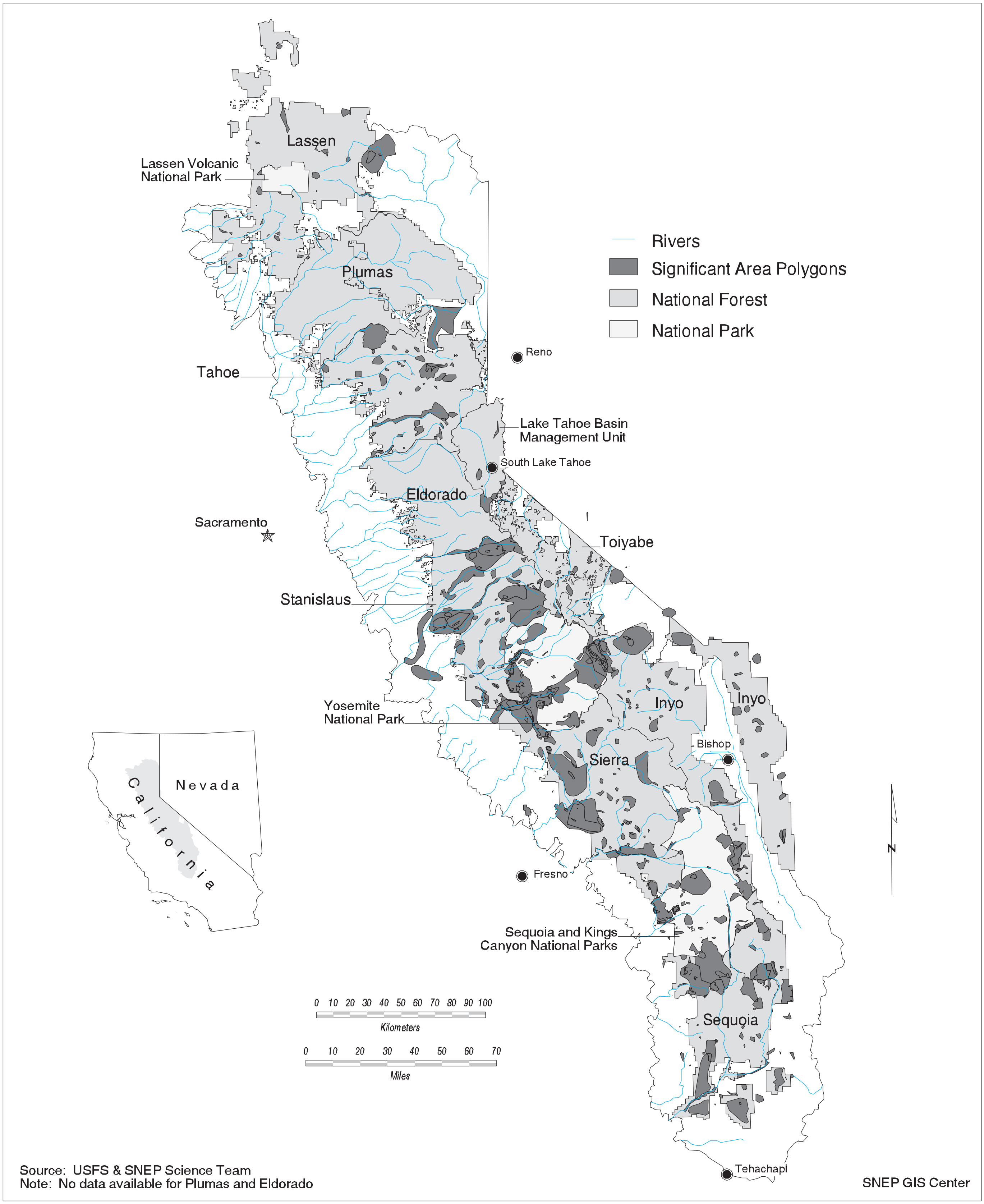

FIGURE 29.3

Significant ecological areas mapped by SNEP (Plumas and El Dorado not included).

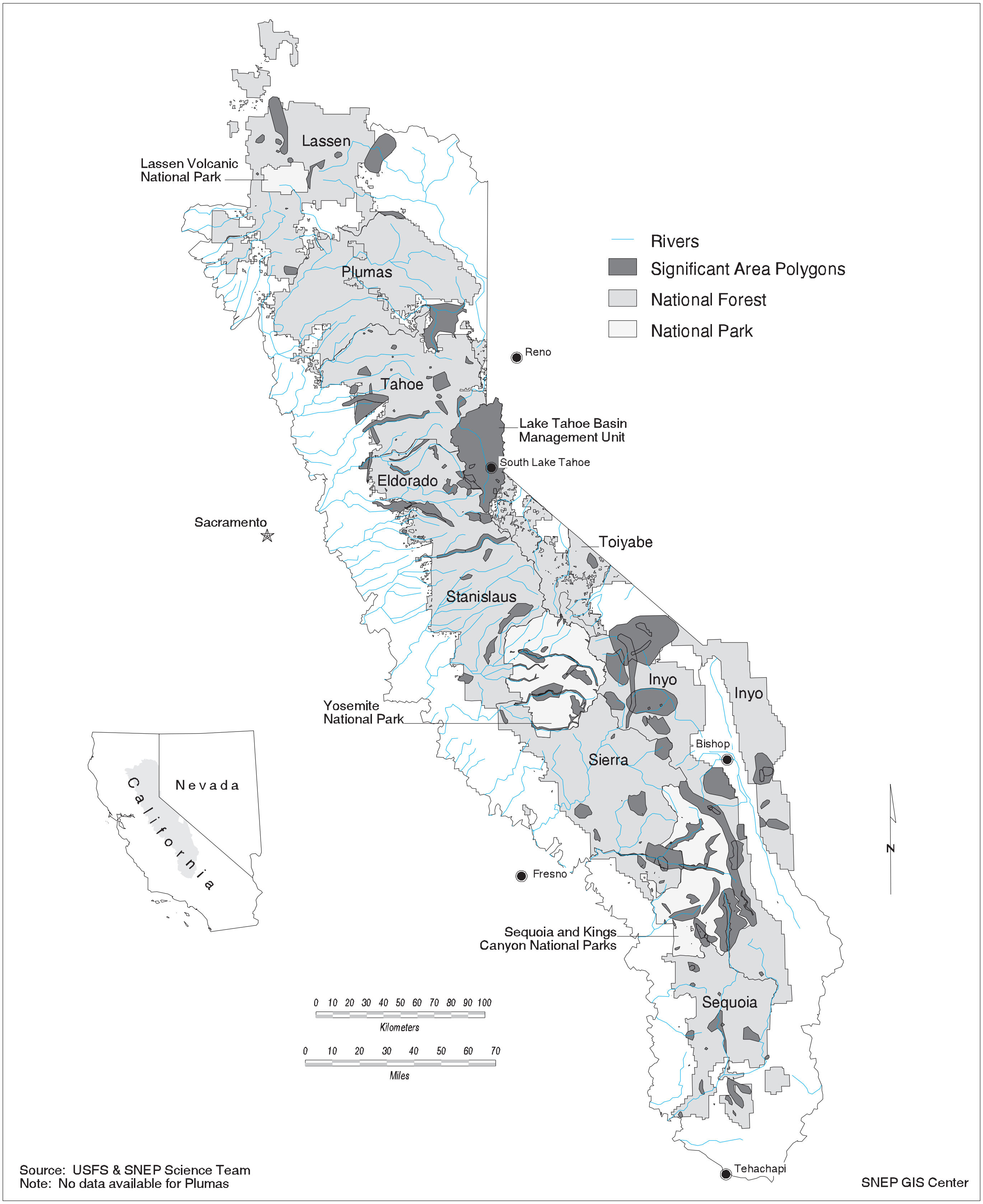

FIGURE 29.4

Significant geological areas mapped by SNEP (Plumas not included).

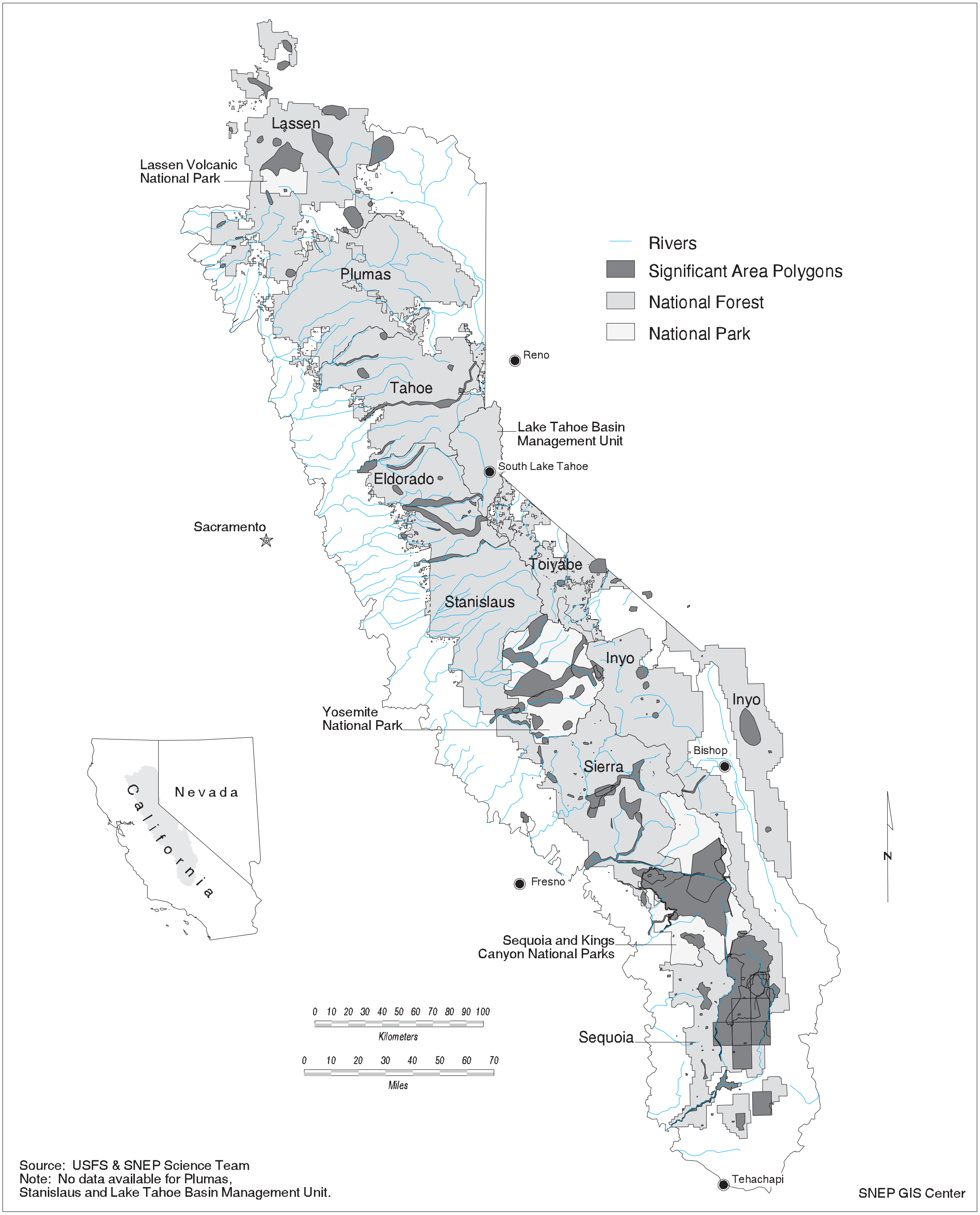

FIGURE 29.5

Significant cultural areas mapped by SNEP (Plumas and Stanislaus Counties and Lake Tahoe Basin Management Unit not included).

TABLE 29.4

Current management status of significant areas mapped by SNEP in the Sierra Nevada (percentage of 945 areas), by national forest and Sierra-wide. Categories are not exclusive or exhaustive.

	Management Category (%)					
Forest	Designated Wilderness	National Park	Protected Designations	Grazing Range Emphasis	Timber Emphasis	Intensive Human Use
Inyo National Forest	4	3	42	28	4	35
Lassen National Forest	6	1	42	18	6	25
Lake Tahoe Basin (USFS)	0	0	12	12	8	21
Tahoe National Forest	0	0	2	19	40	51
Sequoia National Forest	1	0	17	13	16	41
Sequoia–Kings Canyon National Park	9	100	48	2	0	8
Sierra National Forest	6	0	44	17	7	38
Stanislaus National Forest	1	0	23	16	16	29
Toiyabe National Forest	19	0	32	26	0	39
Yosemite National Park	17	100	31	8	0	17
Sierra-wide	4	26	32	14	12	36

be. For instance, grazing and recreation continue in many "protected" designations, such as wilderness, national parks, and research natural areas where significant areas are located. These and other intensive human uses were indicated as posing the greatest threats to maintenance of biodiversity values in the significant areas. This points to the importance of site-specific evaluation of areas to determine local management needs; land designation per se may be insufficient.

Timber harvest and associated activities (road building) are continuing impacts of concern in certain areas of the Sierra Nevada, primarily the northern national forests and west-side forests. Few sites seem to have been affected in the past or at present by mining-related issues or toxic pollutants, and these should not pose large concerns in the future.

OPTIONS FOR THE FUTURE

Objectives in Management of Significant Areas

Significant areas are important to the Sierra Nevada as places of superlative diversity, containing representatives of the collective breadth of biological, geological, and cultural diversity. With this range of diversities, significant areas specifically, and natural areas generally, have (at least) three objectives in ecosystem management of the Sierra Nevada.

Biodiversity Maintenance

A primary role for natural areas is to protect, maintain, and restore biological and physical diversity (California Department of Fish and Game 1991; Cochrane 1986; UNESCO 1974, 1984; World Resources Institute 1991). As examples of in situ conservation, these areas ideally would be sites of sufficient size and condition to enable natural ecological and evolutionary interactions to occur undisturbed. Natural areas at best would protect many levels of biological organization, including genetic, species, community, and ecosystem diversity, over long times and with physical environments intact. Dynamic processes (e.g., disturbance, succession) as well as structural elements are valued within natural areas to maintain natural evolutionary and ecological trajectories.

Reference and Monitoring

Significant areas also serve as important reference (or benchmark) sites for many types of monitoring. They provide baseline sites for studies that compare ecological trends over time, such as succession, recovery from natural disturbance (e.g., fire or insects), response to climate change and anthropogenic impacts (e.g., atmospheric pollution). Such trend analyses are usually done within natural areas and repeated over appropriate time intervals. Natural areas also serve as controls or baselines for studies that compare effects over space, such as management treatment of prescribed fire, disease control, or grazing impacts. In this context, natural areas are the controls, providing sites where information about natural ecological conditions and ranges of variabilities can be obtained and used in nearby lands that are managed more

TABLE 29.5

Past management impacts to SNEP-mapped significant areas in the Sierra Nevada (percentage of 945 areas). Categories are not exclusive or exhaustive.

Impacts	Significant Areas (%)
Logging, harvest	28
Grazing	40
Recreation	51
Roaded areas	27
Mining	10
Pollution	4

intensively. This latter role is increasingly important to ecosystem management, where objectives for landscapes often include reintroduction of natural structure and process. Natural areas provide places to observe and compare natural structure and process.

Research and Education

In addition to studies that provide information directly relevant to ecosystem management, significant areas can be important natural laboratories for research in general. Depending on management, such aspects as minimally disturbed conditions, longtime security, concentration of research studies, and protection of research equipment and experimental plots from vandalism are desirable to research. Similarly, natural areas are important outdoor classrooms for firsthand observation and study.

Integrated Management

SNEP's main assumption about significant area management is that special features for which the areas were selected are worthy of maintaining. Thus, a primary management objective for SNEP significant areas would be to maintain and safeguard the special features (elements) for which each area was recognized, including both short- and long-term needs for viability within the ecological and environmental contexts.

The goals of biodiversity protection, reference, monitoring, and research are best achieved with integrated management. Management of natural areas per se is critical, but equally important is coordinating with other areas managed for similar objectives, with management of adjacent matrix lands, and ultimately within watershed and landscape management (Salwasser 1991).

Natural Area Networks

It would be a major advance in achieving the goals of biodiversity protection, monitoring, and research if natural areas in the Sierra Nevada were better coordinated and managed jointly as part of a bio-geodiversity network (Diedrich et al. 1994; Noss 1983; Noss and Harris 1986; USFS 1992). The large and heterogeneous collection of lands managed for maintenance of special features and natural systems could represent in its cumulative nature a core web over the Sierra Nevada. At present this level of collective network is not achieved in the Sierra Nevada, although some individual programs are administered as integrated networks with regional- to local-level planning, targets, and goals (e.g., USFS Research Natural Areas Program). There is little integrated planning among programs within agencies, however (e.g., USFS programs on wilderness, research natural areas, and special interest areas are not coordinated), and only some interagency collaboration at any level. An interagency natural areas coordinating committee, which functioned to provide communication among agencies on natural areas efforts, has been superseded by the California Executive Biodiversity Council, which does not maintain the natural areas communication function that the original committee attempted.

Communication and functional coordination both among programs within agencies and among agencies necessitates analysis at the ecoprovince level, irrespective of administrative ownership. This would include evaluation of elements (species to ecosystems, cultural to geological) present across the landscape, representation by natural areas of different category and administration, and gaps in representation, and development of a coordinated planning and management strategy among the programs and agencies. The SNEP GAP data (Davis and Stoms 1996) primarily, with the SNEP significant areas inventory and other SNEP assessments, provides inventory and analysis of the first points. It remains an option for agencies and landowners in the Sierra Nevada to coordinate lands and programs into networks so as to achieve higher levels of integration and improved efficiency in conservation functions (Pressey et al. 1993).

Bioregional Integration

In addition to integrating natural areas into regional networks, integrating natural areas with management of matrix and adjacent lands both locally and regionally adds efficiency to achieving conservation goals (Dyer and Holland 1991; Noss 1983). An immediate opportunity is to analyze needs and uses of all lands within a local watershed or landscape (e.g., landscape or watershed analysis [Interagency Team 1994; Manley et al. 1995]), and then manage accordingly (e.g., Mammoth-June case study [Millar 1996a]). Bioregional analyses consider "two-way management," that is, reciprocal needs of adjacent units. For instance, opportunities to provide functionally large habitat areas for organisms that use a natural area may be promoted in multiple-use lands adjacent to natural areas. Depending on the organisms, relatively intensive uses might be applied on lands adjacent to significant areas, as long as specific needs for organisms and processes are provided. Conversely, information obtained within natural areas may serve to inform managers about best practices on adjacent multiple-use lands. For instance, natural areas can provide information that is useful when developing silvicultural prescriptions on adjacent lands, such as number of snags per acre, or size and age-class distribution of dominant trees, density and use of nesting trees by birds, or historic fire intervals (Millar 1996a). High-quality natural areas, where natural processes predominate, can be important places to show managers and public about conditions that exist in minimally disturbed states and thus avert conflict over what "might have been" under no-disturbance management.

SNEP has developed a set of tools for developing scenarios of regional integration for biodiversity protection and restoration (Davis et al. 1996). This model uses preexisting reserves, recognized natural areas, and areas of known value, such as significant areas, as a starting point to build a network. Significant areas as part of this scheme are considered in that report.

As discussed earlier (and in Davis et al. 1996; Davis and Stoms 1996), significant areas specifically and natural areas generally vary in their status regarding biodiversity protection. For objectives of reference/monitoring and research, however, most natural areas in the Sierra Nevada, both those designated and those just recognized as containing special features, are vastly underused. Some areas have become well known for research, based on attributes of high or exemplary diversity, ecological, cultural, or geological integrity, research protection, on-site research facilities, cumulative knowledge gain, and publication familiarity. Areas that currently attract and receive research attention are not necessarily those located in common or widespread ecosystems, nor are they in community types of high interest to managers. Thus, many existing sites could benefit by concerted programs that focus on research in basic biological or physical mechanisms. The University of California Natural Reserve System is exemplary. Monitoring for baseline ecological trends or management treatment comparison is greatly underutilized on natural areas in the Sierra Nevada. Natural scientists and managers alike would benefit by programmatic approaches to monitoring that take advantage of the benchmark conditions offered by natural areas in the Sierra Nevada.

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